

Relationship between the electrical activities of abdominal and back muscles in chronic low back pain

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ABSTRACT

Background: Abdominal and back muscles are integral components in low back mechanics and control. Disturbances in their activities could result in chronic low back pain (LBP). **Objectives:** To assess the relationship between the electromyographic (EMG) activities of abdominal and back muscles and to establish a ratio between the EMG of both groups of muscles. **Methods:** Thirty patients diagnosed with chronic LBP participated in this study. EMG activities, measured as mean root squared, were recorded using surface EMG device during maximum voluntary isometric contraction. Tested muscles were rectus abdominus, external oblique, erector spinae, and lumbar multifidus. **Results:** A strong positive relationship, ipsilaterally, was reported between the EMG of the rectus abdominus and both back muscles ($p < 0.05$). External oblique muscles showed insignificant relationship to the erector spinae and lumbar multifidus muscles on the ipsilateral side ($p > 0.05$). **Conclusion:** Rectus abdominus EMG activities, during maximum voluntary isometric contraction, are positively proportional to the EMG of ipsilateral erector spinae and lumbar multifidus under similar conditions. Patient with LBP induced back muscle weakness could also demonstrate abdominal muscle weakness.

Keywords: EMG; low back pain; muscles; ratio; trunk

1. INTRODUCTION

Low back pain (LBP) is the commonest musculoskeletal problem. It's characterized by a high prevalence rate (Hoy et al., 2012). The nonspecific type of LBP, which has no identifiable cause, represents the majority of the diagnoses with a percentage reach up to 85% of all patients having LBP (Hussien et al., 2017). When turned Chronic, LBP might lead to decreased productivity, increase the rate of sick leaves, and places a huge burden on health systems (Hussein et al., 2019). The pathophysiology and mechanism of action that explain the onset of nonspecific LBP and turning from acute to chronicity is still unclear. Yet, multiple attempts tried to propose different mechanisms. One of the important explanations has been based on the muscular component, the decline in muscular activity, prolongation of



recruitment time, and decreased muscle strength and mass have been recorded in patients with chronic LBP (Hides et al., 2016; Wallwork et al., 2009).

The decline in muscular performance could precipitate further biomechanical problems such as abnormalities in proprioception of the back muscles (Georgy, 2011; Hussien et al., 2017), deterioration in postural mechanism as represented by limits of stability (LOS), postural stability indices (PSIs) (Hussein, 2021; Sipko & Kuczyński, 2013; Soliman et al., 2017), and disruption of the link between trunk flexors and extensor muscles. These groups of antagonists are components of core muscles that play a major role in controlling the intraabdominal pressure (Hemborg et al., 1983) and keeping the lumbosacral angle within normal (Kim et al., 2005). Anterior and anterolateral abdominal muscles along with lumbar multifidus have been reported to participate in lumbar mechanics. For example, the lumbar multifidus controls the lumbar spine on a segmental basis so it can support the lumbar lordotic curve. Moreover, lumbar multifidus augments the axial loading ability of the spine (Hides et al., 2016). On the other hand, decreased abdominal muscles strength and recruitment have been always correlated with the existence of LBP (Hodges et al., 2003).

A limited effort has been conducted to explore the relationship between anterior and posterior trunk muscles either in asymptomatic subjects or in patients with LBP. Studying such relationship, could improve the awareness of health care practitioners regarding the link between the two groups of muscle, elaborate the ability to expect a problem in a muscle if the same problem is found in its antagonists, and could improve the efficiency of the intervention program for patients with LBP. Electromyographic (EMG) is a reliable measure of the electrical activities inside a muscle either at rest or during activities. This method gives a clear picture of muscular strength and recruitment patterns (Lima et al., 2012). And provide reliable information. Being not invasive, surface EMG has been commonly used in clinical settings especially for assessing the effect of back pain on muscular activities (Sanderson et al., 2019; Shah Ali et al., 2019).

The purposes of this study were to explore the relationship between the EMG of abdominal and back muscles and to determine the ratio between the EMG activities of the abdominal and back muscles in chronic LBP.

2. MATERIALS AND METHODS

Design of the study

A correlation study was performed on 30 patients diagnosed with chronic LBP. Measurements were conducted at the EMG Laboratory of a local University in the period between September 2019 and April 2020 on a sample of patients who participated in a study published previously (Elgendy et al., 2020). Registration was granted from the Pan African Clinical Trial Registry (201907878425407).

Participants

The inclusion criteria were continuous or intermittent LBP for 3 months or more (Dewir, 2021), pain localized to the low back area, pain intensity more than 2 on the VAS scale, and age above 20 years. The exclusion criteria were referred pain, nerve root impingement, disc lesions, spinal or abdominal surgery, neurological disease, traumatic muscle weakness, drugs affecting muscle performance or pain sensation, spondylolistheses, obesity (BMI >35), pregnancy.

Outcome measures

During the initial interview, the assessor explained the purposes and procedures of the study, the acceptance of the consent form was signed, and the demographic characteristics were measured and recorded. Additionally, clinical examination of the patients' status, including pain characteristics, intensity, and duration was recorded.

This study was concerned with measuring a single main outcome which is the EMG of selected abdominal and back muscles. EMG was recorded during maximum voluntary isometric contraction (MVIC). The EMG reading was represented as the root mean squared (RMS). Measurements were recorded from abdominal muscles (rectus abdominus and external oblique) and back muscles (erectorspinae and lumbar multifidus). EMG can reliably reflect muscle strength and function through representing electrical potentials (Li et al., 2014; Lima et al., 2012).

Surface EMG (Neuro-EMG-Micro, Neurosoft, Ivanovo, Russia) with dual channels was used to record the RMS. The electrodes' diameter was 10 mm and they were placed with 20 mm distance in between (Hoseinpoor et al., 2014). Skin hair was removed, the skin was cleaned using alcohol then electrodes were placed 3 cm lateral to the midline, parallel to the second lumbar spinous process to record erectorspinae muscle (Silfies et al., 2005). The electrodes were positioned at the level of L5 and adjusted to be parallel to the line between the posterior superior iliac spines and the L1/L2 interspinous space for recording the multifidus fibers.

For the rectus abdominus, electrodes were placed 1 cm proximal and 2 cm lateral to the midline, while external oblique electrodes were placed 15 cm lateral to the umbilicus (Elgendy et al., 2020).

The electrodes were aligned parallel to the tested muscle fibers; the EMG device was set at 1000Hz sampling frequency and 500 μ s sensitivity. All readings were picked up while the patient assuming MVIC (Elgendy et al., 2020). Abdominal EMG was recoded from supine position while prone position was assumed for recording the EMG of the back muscles. Each MIVC was repeated three times and the patient was asked to gradually increase the force to reach an absolute maximum force, then to hold for 10 seconds. A 30-second rest interval was allowed between each trial (Hoseinpoor et al., 2014).

Statistical design

Descriptive statistics such as mean, standard deviation, and ratios (in case of significant correlation) were used to express all data. According to the Shapiro-Wilk test, outcome data were not normally distributed so that, Kendall's Tau b test was conducted to assess the correlation between the EMG of the back and abdominal muscles. The level of significance was $p < 0.05$. SPSS, version 23 for windows (IBM SPSS, Chicago, IL, USA), was used to conduct all statistical tests.

3. RESULTS

Statistical analysis was conducted on 30 subjects with chronic LBP. The sample characteristics were summarized in table 1. The testing of correlation was conducted between each of the following pairs of antagonists (rectus abdominus and erectospinae; rectus abdominus and lumbar multifidus; external oblique and erectospine; external oblique and lumbar multifidus). All measurements were conducted on both sides; correlations were conducted using the data from each side separately. There was a significant positive correlation between the EMG of the right rectus abdominus and right erectospinae ($tb = .698$, $p=0.000$). Similar significant correlation was found between the right rectus abdominus and right lumbar multifidus ($tb = .516$, $p=.000$). On both previous occasions, the correlation was strong (Table 2). Regarding the left side, the EMG of the left rectus abdominus demonstrated a strong positive correlation with erectospinae ($tb = .529$, $p=.000$), while a moderately significant positive correlation was reported between the EMG of the left rectus abdominus and left lumbar multifidus ($tb = .366$, $p=.005$). The EMG of the external oblique muscle was not significantly correlated with the EMG of erectospinae or lumbar multifidus in both sides (Table 2 and figures 1 and 2).

Table 1 Sample characteristics

Characteristics	Mean	SD
Age (year)	33.00	6.04
Weight (Kg)	75.36	5.39
Height (cm)	172.80	5.73
BMI (kg/cm ²)	25.24	1.52
NRS	6.70	1.64

SD, standard deviation; BMI, body mass index; NRS, numeric pain rating scale

Table 2 Kendall's Tau correlation coefficient between the EMG of the anterior and posterior trunk muscles

Side	EMG activities During MIVC	Mean \pm SD Abdominal muscle & Back muscle	Correlation coefficient (tb)	P value
Right side	RA and ES	11.28 \pm 5.013 & 10.58 \pm 4.67	.698	.000
	RA and LM	11.28 \pm 5.013 & 13.31 \pm 4.81	.516	.000
	EO and ES	11.84 \pm 4.54 & 10.58 \pm 4.67	-.028	.830
	EO and LM	11.84 \pm 4.54 & 13.31 \pm 4.81	.057	.656
Left side	RA and ES	11.98 \pm 4.99 & 10.92 \pm 5.27	.529	.000
	RA and LM	11.98 \pm 4.99 & 13.10 \pm 4.79	.366	.005
	EO and ES	10.79 \pm 3.49 & 10.92 \pm 5.27	.059	.218
	EO and LM	10.79 \pm 3.49 & 13.10 \pm 4.79	-.014	.915

EMG, Electromyography; SD, standard deviation; tb , Kendall's Tau coefficient; RA, rectus abdominus; ES, erectospinae; LM, lumbar multifidus; EO, external oblique; p, significant value

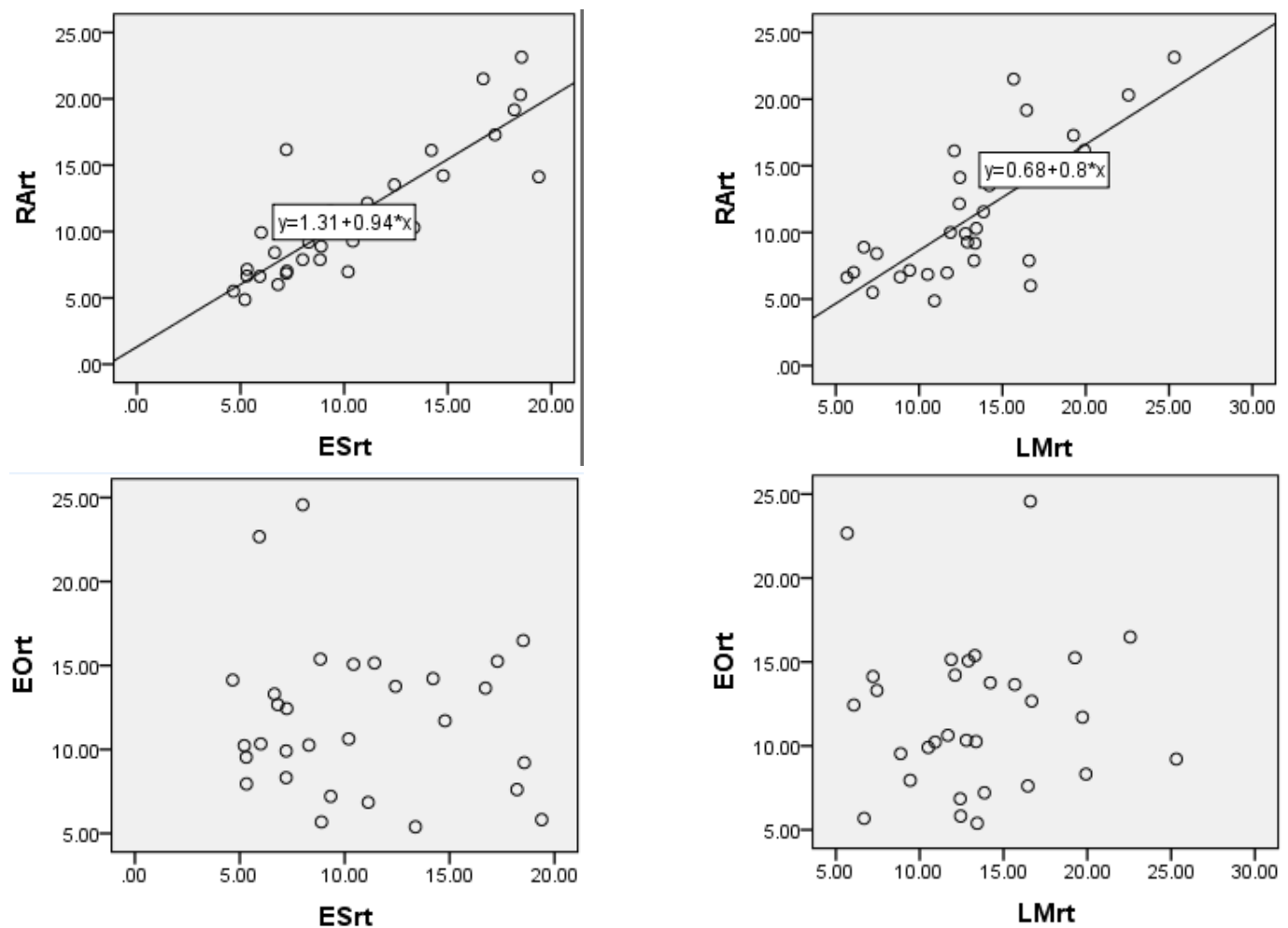
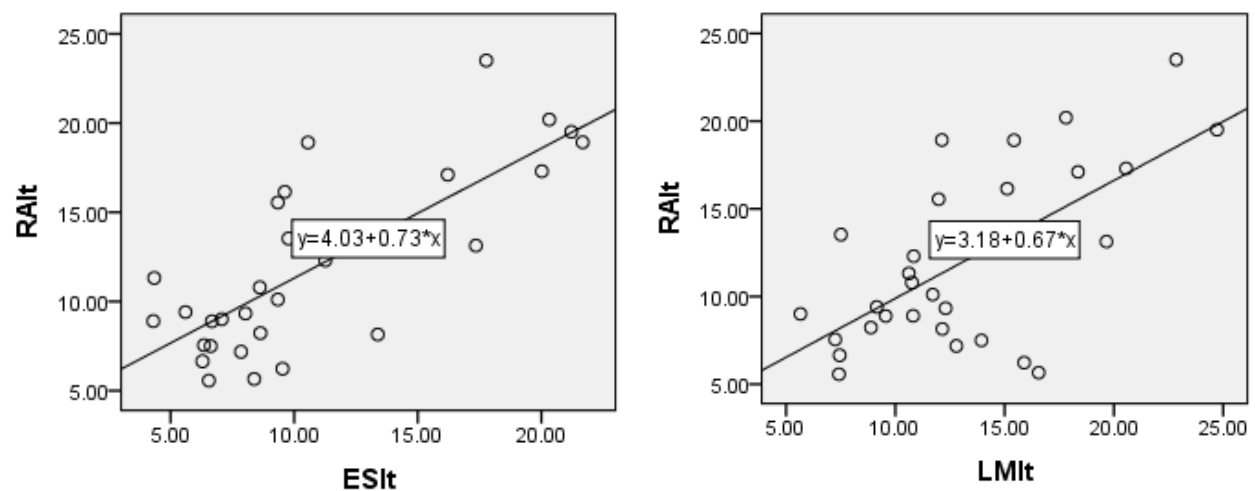


Figure 1 scatter plots for the relationship between abdominal and back muscles in the right side



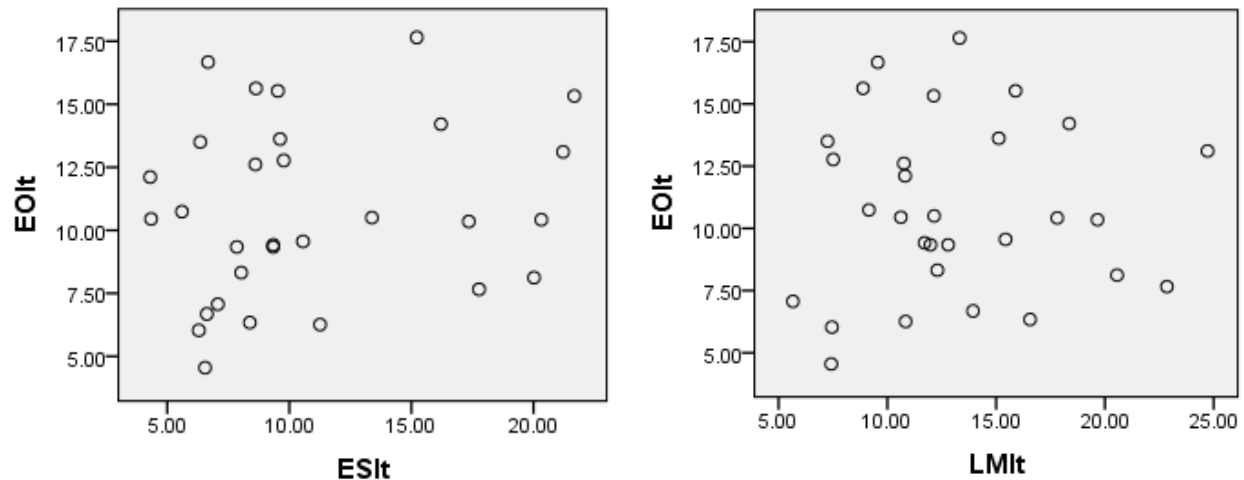


Figure 2 scatter plots for the relationship between abdominal and back muscles in the left side

The ratios between the right rectus abdominus and the right erectrospinae and lumbar multifidus were 1.09, and 0.86 respectively. Additionally, the ratios between the left rectus abdominus and the left erectrospinae and lumbar multifidus were 1.19 and 0.95 respectively (Table 3).

Table 3 rectus abdominus to Erectrospinae & Rectus Abdominus to Lumbar Multifidus EMG ratios during maximum voluntary isometric contraction

Side	Muscles	Ratio Mean \pm SD
Right side	RA to ES	1.09 \pm 0.29
	RA to LM	0.86 \pm 0.26
Left side	RA to ES	1.19 \pm 0.44
	RA to LM	0.95 \pm 0.32

SD, standard deviation; RA, rectus abdominus; ES, erectrospinae; LM, lumbar multifidus

4. DISCUSSION

The current study explored the relationship between the EMG of the abdominal muscles and their antagonists of the back muscles. The findings support the presence of a strong to moderate positive correlation, which means that the increase in EMG activities of the abdominal muscle was usually associated with a proportional increase in the EMG activities of the antagonist back muscle, which proposes a presence of a physiologic link between those groups of muscles. The comparison of the current study results with those published earlier is difficult because, to our best knowledge, the relationship of EMG between the abdominal and back muscles has not been addressed in Literature.

According to a study conducted by Shah Ali et al., (2019) muscle size can reflect the strength of the muscle. They assessed muscle size, using ultrasonography technology, during both rest and activity. The difference in muscle size was used to represent the degree of muscle strength. These findings could be used to argue that smaller muscle size indicate less strength. Patients with chronic LBP demonstrate a decline of the muscle size regarding abdominal and multifidus muscles (Hides et al., 2016). Another study conducted by Sweeney et al reported changes in multifidus muscle size in patients with LBP, especially when measured during certain activities (Sweeney et al., 2014).

Proper addressing of the abdominal muscles along with back muscles during the rehabilitation of LBP patients could yield long-term pain relief (Unsgaard-Tøndel et al., 2012). Additionally, knowledge about the exact ratio between the EMG of the abdominal and back muscles in LBP and comparisons with a standard reference of the healthy subjects could provide useful information during rehabilitation. Healthcare providers could precisely determine the amount of deviation in this ratio and try to regain it to normal standards through appropriate interventions.

Future research should address the relationship between the strength, activation pattern, EMG of the abdominal and back muscles during rest and voluntary contraction. The ratio between the activities of these antagonist groups of muscles should also be

established in order to provide normal reference values. This study was conducted on a relatively low number of patients with LBP which could affect the accuracy of the results. Using surface electrodes, however having multiple advantages, it cannot provide accurate isolation of a specific muscle. Additionally, the variation of the application techniques of surface EMG could affect the results.

5. CONCLUSION

EMG activity of the abdominal muscles is positively correlated with those of the antagonist back muscles. Chronic LBP could result in weakness of abdominal as well as back muscles. Patient with chronic LBP should undergo strengthening exercises for abdominal as well as back muscles.

Author's contributions

The author did all the work in this study

Ethical approval

Local university ethical committee board no: P. T. REC/012/002159.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

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